Current	**Mean drift velocity**

Learning objectives	**MUST (C)**	Identify and define the components in the equation I = Anev
	SHOULD (B)	Recognise the groups of substances with different conducting abilities, and their technical classification
	COULD (A/A*)	Perform calculations using I = Anev and understand relationships between the terms

STARTER: Use the mark schemes to self-assess your homework for Lesson 2.

Extension: A 1 cm strip of copper wire has been cut. It is not connected to anything. Are the delocalised (free) electrons inside it moving? If not, why not? If so, how are they moving?

Current	**Mean drift velocity**
MUST (6)	Identify and define the components in the equation I = Anev

We are going to use a different equation to represent current in a wire:

$$I = Anev$$

Can you work out what A, n, e and v represent?

(Hint: It will help you to recall that current is defined by the rate of flow of charge. How would you work out how much charge passes a point in the wire in one second?)

Extension: what do we mean by a 'good conductor'?

A	cross-sectional area (m^2)
n	number density - number of free electrons per volume ($/m^3$)
e	elemental charge (C)
v	mean drift velocity of an electron (m/s)

Why 'mean drift velocity'? why not just 'velocity'?

Current	**Mean drift velocity**
MUST (6)	Identify and define the components in the equation I = Anev

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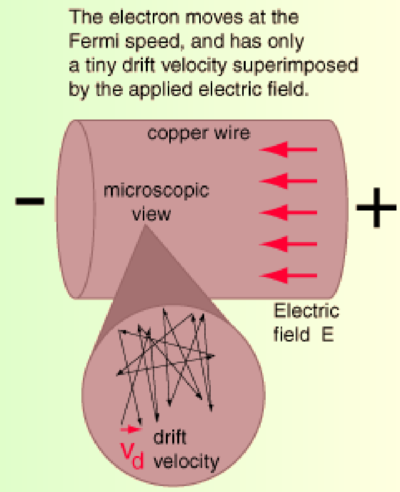
What's mean drift velocity? Use the diagram to help you work it out.



The velocity of an electron represents how fast it is moving. However; as it constantly hits ions, it is not consistently moving forwards.

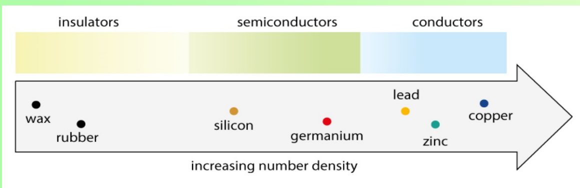
Mean drift velocity is the average distance that an electron moves along the wire (to the higher potential) per second.

Extension: in any given wire, what's the relationship between drift velocity and current? How can you show this?

Current	**Mean drift velocity**
SHOULD (7)	Recognise the groups of substances with different conducting abilities, and their technical classification

Look again at the equation. Which of the factors is a property of a **specific material** (and won't be affected by the shape of a wire, electric field applied....)

$$I = Anev$$

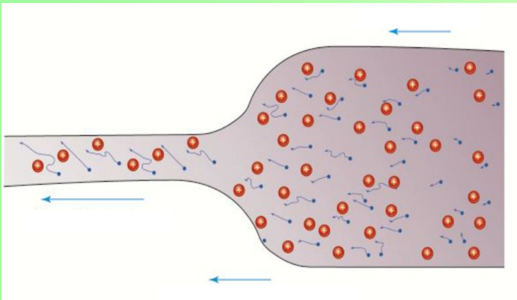


Material	Type	n /m^{-3} (at 300 K)
copper	conductor	8.5×10^{28}
zinc	conductor	6.6×10^{28}
germanium	semiconductor	2.0×10^{18}
silicon	semiconductor	8.7×10^{15}

Current	**Mean drift velocity**
COULD (8/9)	Perform calculations using I = Anev and understand relationships between the terms

What happens when a wire narrows?

$$I = Anev$$



How does this link to our work in the last lesson?

Step 1: Identify the equation that relates v and A.

$$I = Anev$$

Rearrange to make v the subject. $v = \frac{I}{Ane}$

Step 2: Examine the effect of changing A.

According to Kirchhoff's first law, the current in the wire is the same. The elementary charge e and the number density n are also constants, and n does not change because it is the same material.

Therefore, $v \propto \frac{1}{A}$

If the radius halves the cross-sectional area will decrease by a factor of 4.

As a result the mean drift velocity must increase by a factor of 4.

Current	**Mean drift velocity**
COULD (8/9)	Perform calculations using I = Anev and understand relationships between the terms

Now try the problems at the end of section 8.4. Omit question 1.

2 $I = A\,n\,e\,v$ and n for copper $= 8.5 \times 10^{28}\ \text{m}^{-3}$ [1]

$I = 5.50 \times 10^{-8} \times 8.5 \times 10^{28} \times 1.60 \times 10^{-19} \times 2.0 \times 10^{-3}$ [1]

$I = 1.5\ \text{A}$ (2 s.f.) [1]

3 $I = A\,n\,e\,v$ therefore $v = \dfrac{I}{A\,n\,e}$ [1]

$v = \dfrac{500 \times 10^{-3}}{7.10 \times 10^{-6} \times 5.86 \times 10^{28} \times 1.60 \times 10^{-19}}$ [1]

$v = 7.51 \times 10^{-6}\ \text{m s}^{-1}$ (3 s.f.) [1]

4 a From $v = \dfrac{I}{A\,n\,e}$ it follows that $v \propto \dfrac{1}{A}$ [1]

Therefore, if the cross-sectional area increases, the mean drift velocity decreases. [1]

b From $v = \dfrac{I}{A\,n\,e}$ it follows that $v \propto \dfrac{1}{n}$. [1]

As copper has a higher n than zinc, n increases, so the mean drift velocity decreases. [1]

c From $v = \dfrac{I}{A\,n\,e}$ it follows that $v \propto \dfrac{1}{A}$. [1].

As $A = \pi r^2$, if r decreases by a factor of 3, A will decrease by a factor of 9 (3^2). [1]

As A decreases by a factor of 9, the mean drift velocity must increase by a factor of 9. [1]

5 $I = A\,n\,e\,v$; therefore, $v = \dfrac{I}{A\,n\,e}$ [1]

$A = \pi r^2$; therefore, $A = \pi \times \left(\dfrac{1.0 \times 10^{-3}}{2}\right)^2$ [1]

$= 7.85... \times 10^{-7}\ \text{m}^2$

$v = \dfrac{I}{A\,n\,e} = \dfrac{3.0 \times 10^{-3}}{7.85... \times 10^{-7} \times 6.6 \times 10^{28} \times 1.60 \times 10^{-19}}$

$v = 3.6 \times 10^{-7}\ \text{ms}^{-1}$ (2 s.f.) [1]

6 $I = A\,n\,e\,v$; therefore, $n = \dfrac{I}{A\,v\,e}$ [1]

$n = \dfrac{I}{A\,v\,e} = \dfrac{12 \times 10^{-3}}{8.2 \times 10^{-6} \times 72 \times 1.60 \times 10^{-19}}$ [1]

$n = 1.27... \times 10^{20}$ [1]

Giving a ratio of $\dfrac{1.27... \times 10^{20}}{8.5 \times 10^{28}}$ or 1.5×10^{-9} : 1 (2 s.f.) [1]

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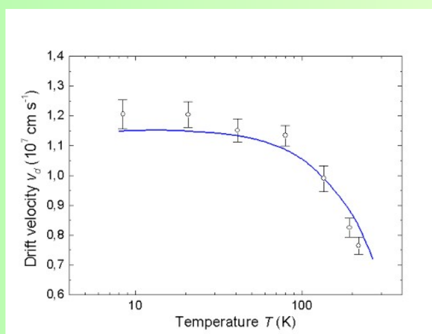
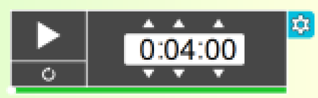
PLENARY: We know that a higher temperature lowers the conductivity of a wire. Can you explain this with reference to the equation we've seen today Which factor is affected?

Example *v*-temperature relationship





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